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(54) Screw Socket for an Artificial Hip Joint

(57) The invention concerns a screw socket for an artificial hip joint, with a self-cutting V-shaped, buttress, trapezoidal or round thread on a thread base of a screw socket body. In order to facilitate screwing into hard bone material, each thread segment is formed, in the front region in the direction of rotation, with a cutting edge with a clearance face so that, in the section in a plane which is located in the front region with parallel displacement relative to a plane tangential to the thread base (18), the said cutting edge has a clearance angle α. Preferably, the cutting edge also has a cutting rake γ in the said section.

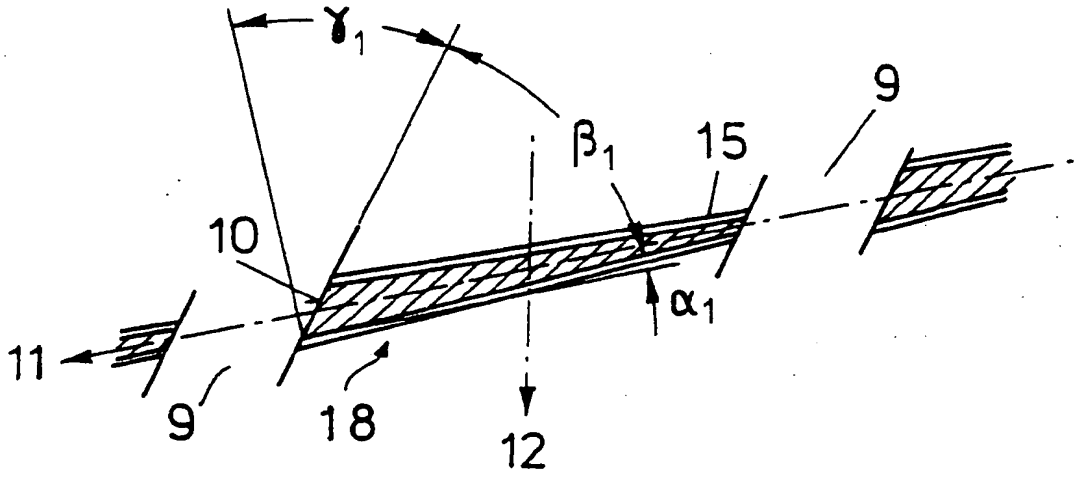

Fig. 12

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Description

The invention concerns a screw socket for an artificial hip joint, which has a self-cutting V-shaped, buttress, trapezoidal or round thread on a thread base of a screw socket body.

Such a screw socket is known, e.g. from the European Patent Specification EP 0 065 482 B1, which describes a socket with a threaded ring into which a socket inlay of plastics material can be inserted. The thread base of the threaded ring is hemispherical, i.e., it lies on a spherical zone and, in the embodiment example depicted, carries a buttress thread. The thread segments of the self-cutting thread are interrupted by sunk thread grooves through which bone material removed during screwing-in is passed outwards. The thread segments have plane front faces perpendicular to the direction of rotation.

There are extensive studies concerning the screwing-in behaviour of screw sockets, see e.g. "Mechanische Integration von Schraubpfannen" ("Mechanical Integration of Screw Sockets"), Dr. Ulrich Witzel, Georg Thieme Verlag, 1996. When the known screw sockets are screwed into the complementary recess prepared in the acetabulum, the self-cutting thread penetrates the bone material, the screwing-in torque increasing up to a maximum value at which the screw socket has attained the end position, whereby the maximum torque for typical screw sockets and typical bone material can be in the range of 15 to 30 Nm. In the case of altered acetabulum bone material, particularly in the case of the bone material being greatly increased in strength due to sclerosis or calcification, substantially higher torques can be required to screw in the screw socket. In extreme cases, it has happened that it was necessary to apply such high torques that the patient had to be held in position during the screwing-in operation so that he did not turn on the operating table with the screw socket.

In machine construction, it is known in principle that tool cutting edges can have a ground surface. A cutting tool is depicted schematically in cross section in Figure 1, for the purpose of representing the geometric parameters. In cutting the workpiece 2, the clearance face 1 of the tool forms a clearance angle α with the workpiece surface 6. Located between the cutting face 3 of the tool, over which the cutting 4 is discharged, and the face 5, which is perpendicular to the workpiece surface 6, is the cutting rake γ. The clearance face 1 and the cutting face 3 enclose the wedge angle β.

Also known in the existing art are screw sockets with a flat thread, i.e., with thread teeth which are essentially rectangular in the profile cross-section, as depicted in Figure 2, wherein, for the sake of simplicity, only two thread teeth 7 are depicted on the screw socket body 8. Figure 3 shows a section along the plane A-B from Figure 2. In the case of such a flat thread, the cutting 4 being depicted schematically by an arrow in Figure 3, the material-removing cut is effected by an increasing radius R (external radius of the thread contour) due to the pitch of the thread on the screw socket body 8 which can be e.g. conical or, as depicted in Figure 2, hemispherical. The external radius R of the following thread segment, which is separated from the preceding segment by a sunk thread groove 9, is therefore shifted to a somewhat larger radius and consequently again provides for a material-removing cut into the bone material. In the case of screw sockets with a flat thread, embodiments are known in which, in the profile longitudinal section of the thread segments as depicted in Figure 3, the flat thread has a clearance angle α' which is achieved through a rectilinear bevelling of the thread segment. This bevelling produces a loss surface 13, i. e., the surface which is lost to the thread for anchoring in the bone material. There are also known flat threads which, in the profile longitudinal section, are so formed in their front region that they have a cutting rake γ', as depicted in Figure 4.

The known V-shaped threads (as also the known buttress, trapezoidal or round threads) on screw sockets do not have any particular cutting edge conformation. Figure 5 depicts, by way of example, a cut-off partial view of a screw socket with a V-shaped thread, wherein, for the sake of simplicity, only two thread teeth are shown in the profile cross-section on the screw socket body. Figure 6 depicts a section along the plane A-B from Figure 5. In the longitudinal view of the thread segments from Figure 6, the V-shaped thread has neither clearance angle α' nor a cutting rake γ'.

Considered below is a further section through the thread segments, namely, along the surface C-D from Figure 6, i.e., essentially a section at constant height above the thread base 18. Such a section is shown in Figure 7, wherein the arrow 12 denotes the rotational axis of the screw socket. On screwing in, the thread segment front face 10 moves in the direction of motion 11. In the case of the thread from Figure 7, there are neither clearance angles α_1, α_2 nor cutting rakes γ_1, γ_2 in this section, i.e., the wedge angles β_1, β_2 are each 90° (the indices 1 and 2 denote the cutting edges on both sides of the front face 10).

In the case of the thread segments fashioned thus, the thread segment front faces primarily displace the bone material upon screwing in. At most, they cut if bone material is forced back into the thread grooves 9. This also applies to thread segments which are separated by thread grooves 9 which run obliquely relative to the direction of screwing in, such as those depicted in Figure 8 which is otherwise the same as Figure 7. Upon screwing in, such threads likewise primarily effect a displacement of the bone material, without a genuine cutting action. In addition, the edges of the thread segments are rounded in the production of the screw sockets, sandblasting normally being effected for the purpose of surface treatment, as indicated by the radius of curvature r in Figure 8.

Overall, therefore, in the case of screw sockets with

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a V-shaped thread, as also those with a buttress, trapezoidal or round thread, problems always occur on screwing in if the bone material is very hard due to sclerotic alterations and displacement by the thread is virtually no longer possible. In practice, the problems indicated above occur, in that extremely high torques have to be applied in order to screw the screw socket into its end position.

However, since a V-shaped thread has biomechanical advantages over a flat thread in respect of the design and stability of the osseous implant socket, the known V-shaped threads must be modified and improved in respect of their cutting effects.

It is therefore the object of the present invention to create a screw socket with a V-shaped, buttress, trapezoidal or round thread which can be screw into hard bone material with a lesser amount of torque than the screw sockets known hitherto.

This object is achieved by the characterizing features of Claim 1 in association with the pre-characterizing clause of the said claim. Advantageous embodiments of the invention are detailed in the sub-claims.

Accordingly, the front of each thread segment in the direction of rotation is formed with a cutting edge with a clearance face so that, in the section in a plane which is located at the front of the thread segment with parallel displacement relative to a plane tangential to the thread base, the said cutting edge has a clearance angle α.

Moreover, the cutting edge is preferably formed so that, in the said section, it also has a cutting rake γ. The clearance angle α and the cutting rake γ are preferably greater than 0.01 (radian measure).

It is particularly preferable to fashion the thread segment cutting edges as spatial cutting edges which not only have a clearance angle α in the first-mentioned section parallel to the thread base, but also, in addition, have a clearance face with a clearance angle α' in the profile longitudinal section (i.e., through a plane located, tangentially relative to the spatial spiral line of the thread course, in the front region of the thread segment). The claimed spatial cutting edge design is completed if the thread segment in the last-mentioned profile longitudinal section also has a cutting rake γ'.

Furthermore, it is preferable that the cutting edge of each thread segment is formed so that, in the section parallel to the thread base, its front cutting edge projects over the extended envelope of the leading thread segment end in the direction of screwing in. By this means, a directly acting cutting edge is achieved which would be effective even if no bone material were forced back elastically behind the leading thread segment end.

According to a further aspect of the invention, there is created a screw socket for an artificial hip joint with a self-cutting thread on a thread base of a screw socket body which is characterized in that each thread segment is formed, in the front region in the direction of rotation, with a cutting edge with a clearance face so that, in the section in a plane which is located in the front region with parallel displacement relative to a plane tangential to the thread base, the said cutting edge has a cutting rake γ and, in this section, is widened in the front region so that, due to the widening, the front cutting edge projects over the envelope of the leading thread segment end in the direction of rotation.

The invention is described below with reference to embodiment examples described in the drawings, wherein:

Figure 1: shows a schematic sectional representation of a tool, for the purpose of explaining the geometric tool parameters;

Figure 2: shows a partial view of a screw socket from the existing art, in the section through a plane containing the rotational axis 12 of the screw socket;

Figure 3: shows a sectional view of the plane A-B from Figure 2;

Figure 4: shows a view as in Figure 3 for another screw socket from the existing art;

Figure 5: shows a partial view of a screw socket, in the section through a plane containing the rotational axis 12, a screw socket from the existing art with a V-shaped thread being depicted;

Figure 6: shows a sectional view along the plane A-B from Figure 5;

Figure 7: shows a section through the thread, along the surface C-D from Figure 6;

Figure 8: shows a representation as in Figure 7 for another known thread;

Figures 9 to 11: show representations of thread segments according to the invention in sectional views corresponding to the view from Figures 3 and 4;

Figure 12: shows a section through the thread, corresponding to the view in Figures 7 and 8, for a screw socket according to the invention; and

Figures 13 and 14: show views, corresponding to Figure 12, of alternative embodiments.

Figure 12 depicts a section through a screw socket, corresponding to the section through the surface C-D from Figure 6, i.e., the thread segments have been cut open at a certain height above the thread base 18. In the case of a hemispherical screw socket, the section through the surface C-D corresponds to a section along a spherical surface. The claims, by contrast, are based on a section through a plane which lies in the front region

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of the thread segment, with parallel displacement relative to a plane tangential to the thread base. In a first approximation, the last-mentioned sectional representation corresponds locally, in the front region, in the direction of rotation, of the cutting edge of the thread segment, to the section depicted in Figure 12.

In the section depicted in Figure 12, the thread segment tapers away from its front face 10 towards the next thread groove 9. The cut surface of the thread segment is represented by hatched lines and the reference 15 denotes the root lines of the thread segment on the thread base 18 (cf. Figure 5). The result of the tapering of the thread segments in the longitudinal direction is that the front face 10 has a clearance angle at each of its outer cutting edges (only the clearance angle α_1 on one side is identified).

The decreasing width of the thread segment along its length has the further effect that the cutting edges of the thread segment project on both sides over the extended envelope of the leading thread segment end and thus create directly acting cutting edges which are effective even if no bone material is forced back elastically into the thread groove 9 located in front of the cutting edges.

Figure 13 shows a view as in Figure 12, for an alternative embodiment. In the embodiment according to Figure 13, a clearance angle α_1, in combination with a directly acting wedge angle β_1 and a cutting rake γ_1, is provided only on the pole side, or that of the direction of screwing in, of the front face 10 of the thread segment.

According to an alternative aspect, the thread segment can also be realized, in the sectional representation of Figure 13, in such a way that it does not have a clearance angle α_1, but the cutting edge located at the front in the direction of screwing in is replaced by a cutting lip having the width b, as depicted in Figure 14, which in practice achieves an effect similar to a clearance angle. The thread segment is thus fashioned so that it is widened in the region of the cutting lip and is then recessed by a step a. The width b of the cutting lip can be e.g. 0.3 mm and the depth a behind the cutting lip e.g. 0.05 mm.

The figures 9 to 11 depict views of the thread according to a sectional representation through the plane A-B from Figure 5. In the case of the embodiment depicted in Figure 9, by contrast with the known thread depicted in Figure 6, the height of the thread contour 14 above the base 18 decreases. By this means, a clearance angle α' of the cutting edge of the thread segment is achieved in this sectional plane. The height of the thread segment above the thread root decreases in the course of the length of a thread segment, from the starting point to the end point in the direction of rotation.

As a result, however, the curved thread contour 14 with a continuously decreasing thread height acquires a greater thread segment surface by contrast with a straight, flattened thread contour as in Figure 3 and Figure 4, i.e., the loss surface 13 indicated in Figures 3 and 10 is minimized. The loss surface 13 is the surface which is effectively lost to the thread for bedding or anchoring in the bone. The effectuation of the clearance angle α' by a continuously curved thread contour with a decreasing height above the thread base is therefore advantageous in respect of a better anchorage of the screw socket in the bone.

Figures 10 and 11 depict alternative designs of the thread grooves 9, which result in different forms of the cutting edge. In the case of the embodiment depicted in Figure 11, the thread groove 9 is sunk obliquely so that, in this sectional view, the cutting edge has a cutting rake γ'.

With its clearance angle α', this thread contour primarily compensates the geometrically determined increase in diameter after a thread crest which, in the absence of a clearance angle, i.e., $\alpha' = 0$, would result in a clearance stoppage of the outer contour of the thread on the osseous socket.

Claims

1. Screw socket for an artificial hip joint, with a self-cutting V-shaped, buttress, trapezoidal or round thread on a thread base of a screw socket body, characterized in that each thread segment, in the front region in the direction of rotation, is formed with a cutting edge with a clearance face so that, in the section in a plane which is located in the front region with parallel displacement relative to a plane tangential to the thread base (18), the said cutting edge has a clearance angle α.

2. Screw socket according to Claim 1, characterized in that, in the front region of each thread segment, the cutting edge is additionally formed with a cutting face so that, in the section in the plane which is located with parallel displacement relative to the plane tangential to the thread base (18), the said cutting edge has a cutting rake γ.

3. Screw socket according to Claim 1, characterized in that, in a section at a constant height above the thread base, the width of each thread segment decreases continuously from the front region in the direction of rotation along the entire length of the thread segment.

4. Screw socket according to one of the preceding Claims, characterized in that each cutting edge is formed so that, in the section in the plane which is located in the region of the cutting edge with parallel displacement relative to a plane tangential to the thread base, its front cutting edge projects, in the direction of screwing in, over the envelope of the leading thread segment end in the direction of rotation.

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5. Screw socket according to one of the preceding Claims, characterized in that the clearance angle α is greater than 0.01 (radian measure).

6. Screw socket according to one of Claims 2 to 5, characterized in that the cutting rake γ is greater than 0.01 (radian measure).

7. Screw socket according to one of the preceding Claims, characterized in that the front region, in the direction of rotation, of each thread segment is formed with a further cutting edge with a clearance face so that, in the profile longitudinal section (i.e., through a plane located, tangentially relative to the spatial spiral line of the thread course, in the front region of the thread segment), the thread segment has a clearance angle α'.

8. Screw socket according to Claim 7, characterized in that the further cutting face is additionally formed with a cutting face so that, in the profile longitudinal section, the thread segment has a cutting rake γ'.

9. Screw socket according to Claim 7, characterized in that the clearance angle α' is effected through a continuously curved thread contour (14) whose height above the thread base (18) decreases.

10. Screw socket according to Claim 7, characterized in that the clearance angle α is greater than 0.01 (radian measure).

11. Screw socket according to Claim 8, characterized in that the cutting rake γ' is greater than 0.01 (radian measure).

12. Screw socket for an artificial hip joint, with a self-cutting thread on a thread base of a screw socket body, characterized in that each thread segment, in the front region in the direction of rotation (11), is formed with a cutting edge with a clearance face so that, in the section in a plane which is located in the front region with parallel displacement relative to a plane tangential to the thread base (18), the said cutting edge has a cutting rake γ and, in this section, is widened in the front region so that, due to the widening, the front cutting edge projects over the envelope of the leading thread segment in the direction of rotation.

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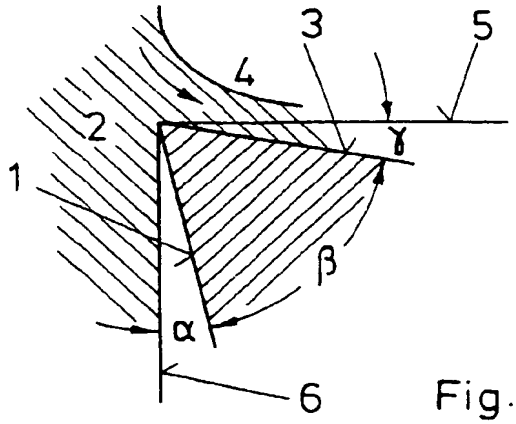

Fig. 1

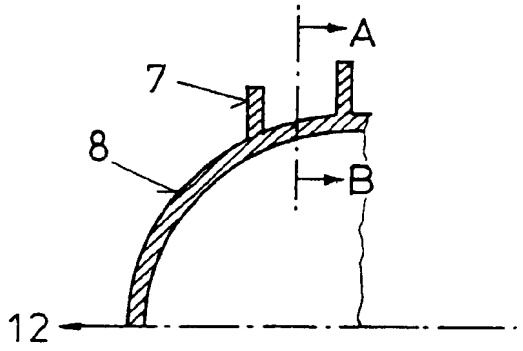

Fig. 2

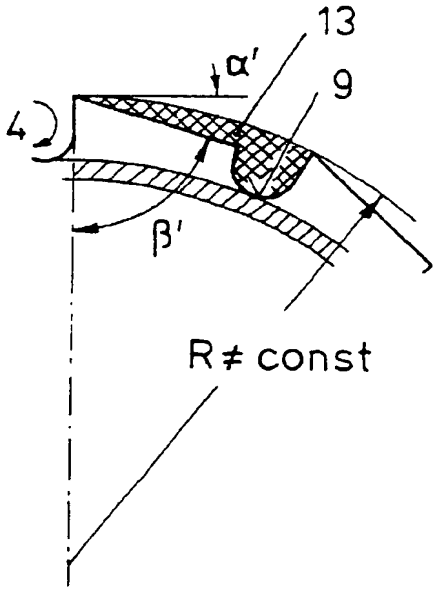

Fig. 3

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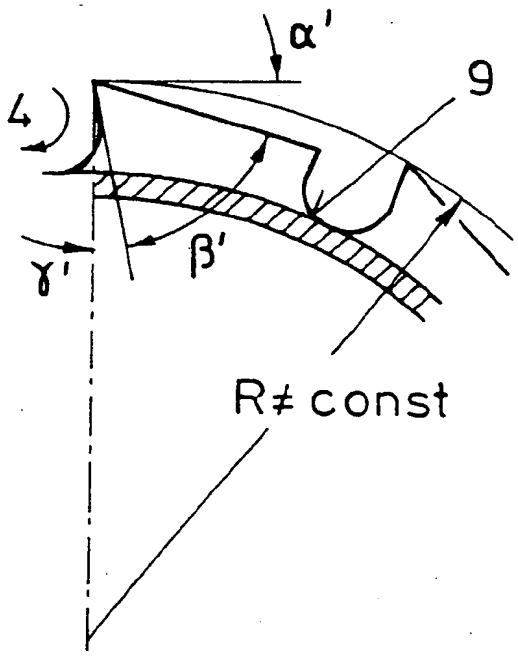

Fig.4

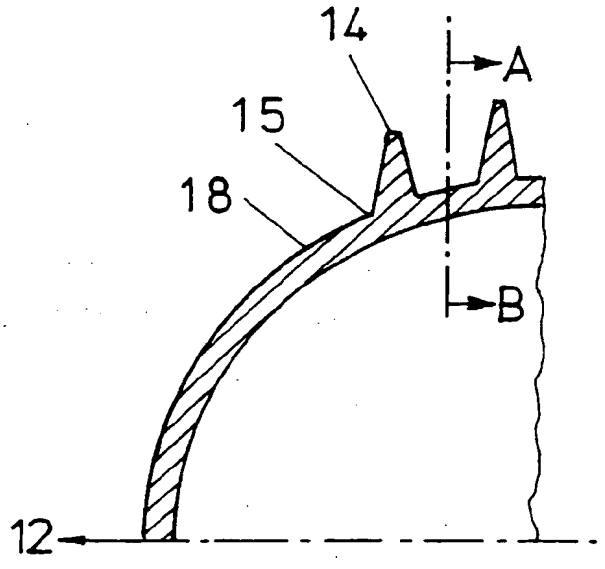

Fig.5

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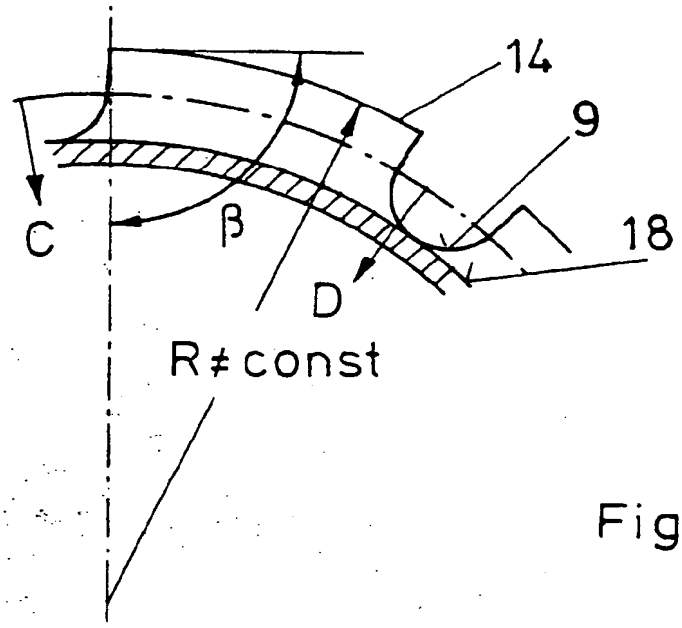

Fig. 6

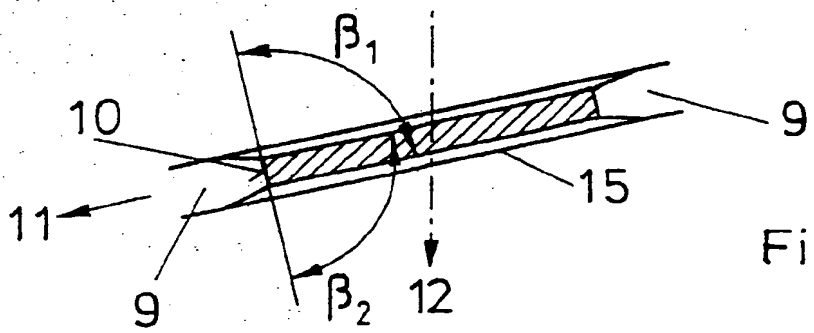

Fig. 7

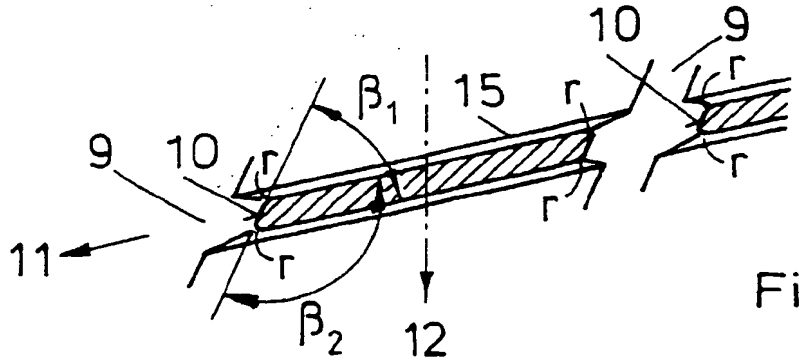

Fig. 8

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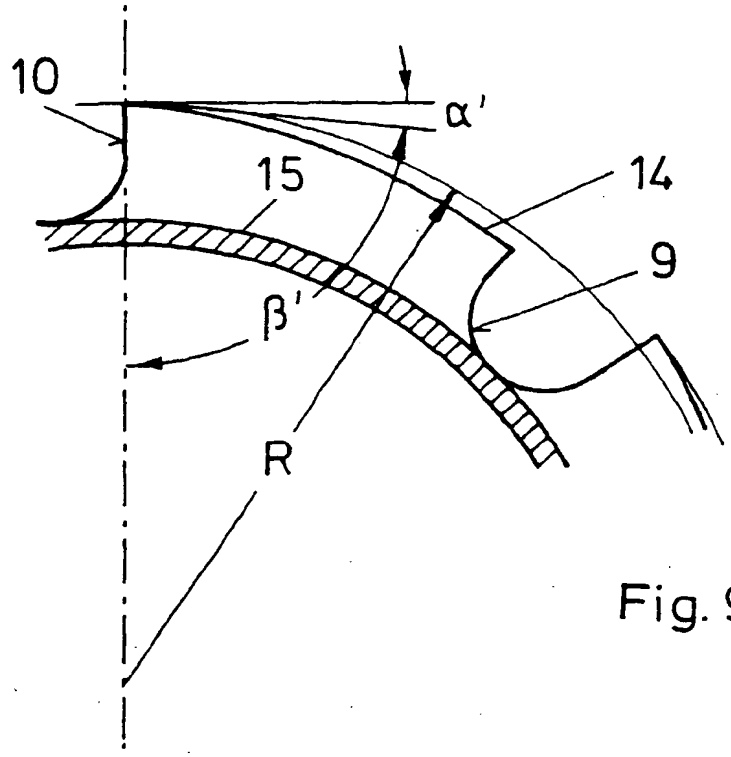

Fig. 9

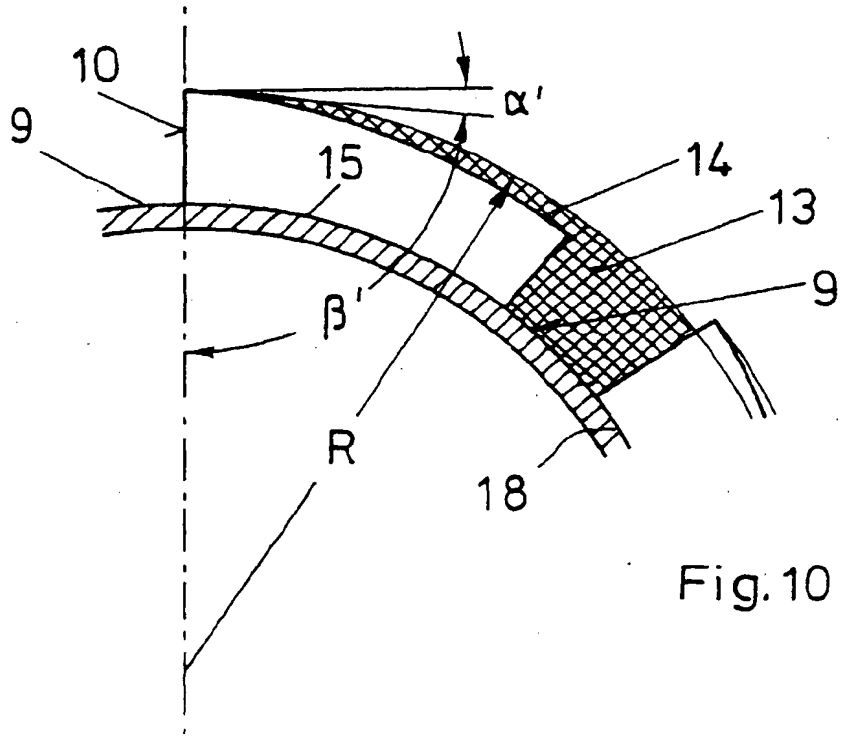

Fig. 10

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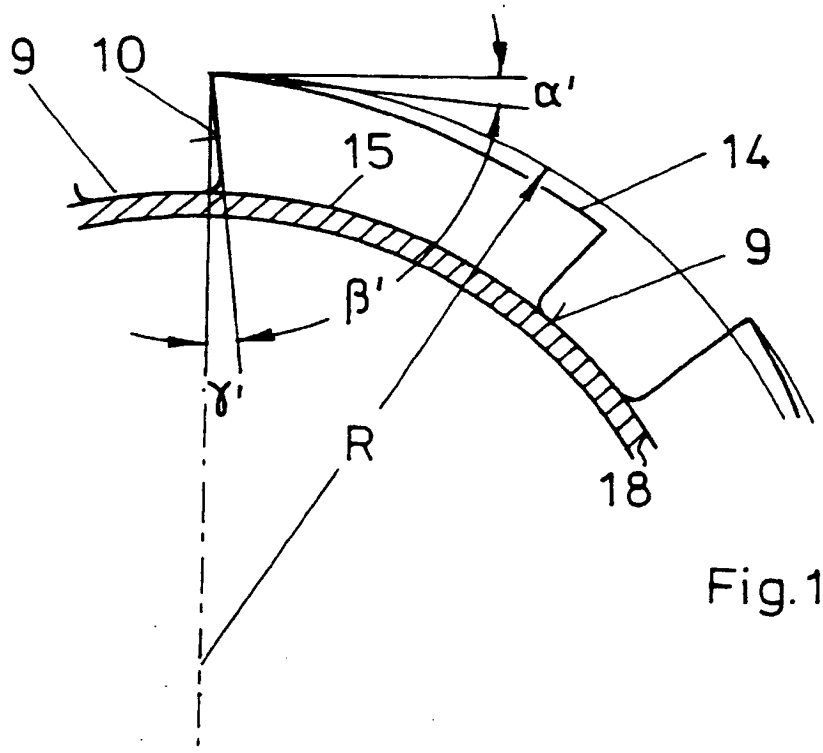

Fig.11

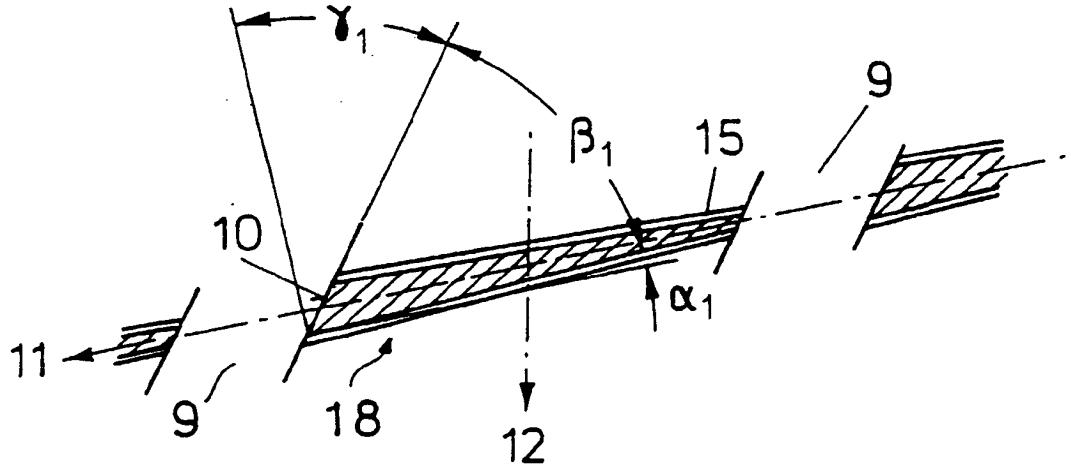

Fig.12

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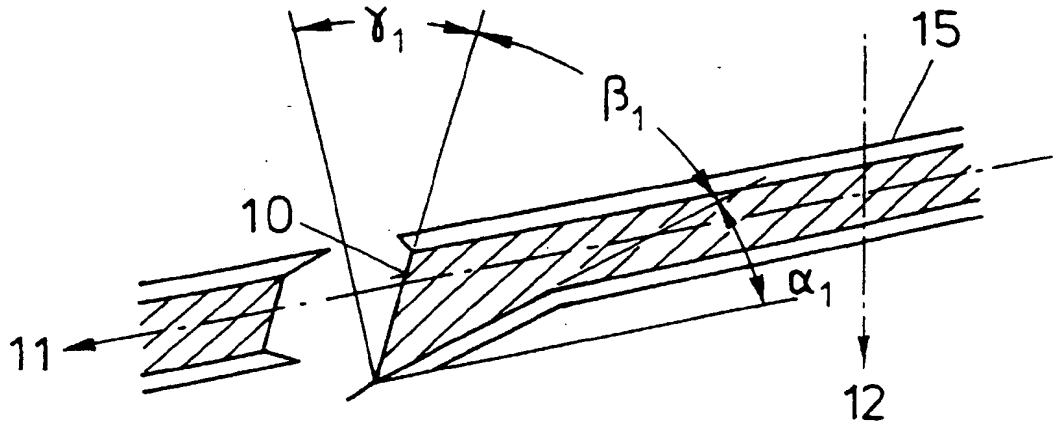

Fig.13

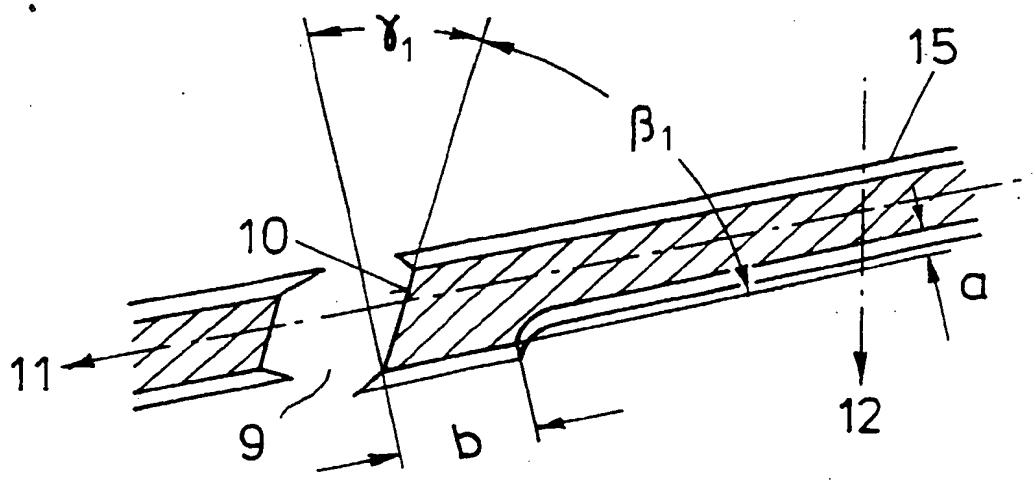

Fig. 14

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(54) Screw Socket for an Artificial Hip Joint

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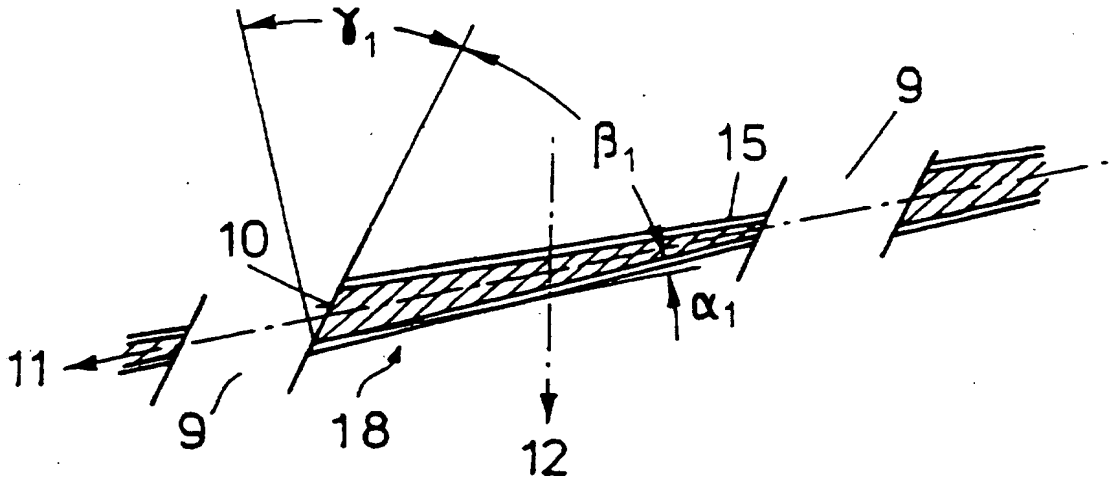

Fig.12

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European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 25 0211

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X Y	DE 29 50 536 A (HOWMEDICA INTERNATIONAL, INC.) 2 July 1981 (1981-07-02) * page 12, line 16 - line 19; figure 1 *	1 12	A61F2/34
X Y	EP 0 358 345 A (MINNESOTA MINING AND MANUFACTURING COMPANY) 14 March 1990 (1990-03-14) * column 2, line 7 - line 14; figure 1 *	1 12	
Y A	US 4 894 064 A (MARTIN IMHOF) 16 January 1990 (1990-01-16) * column 3, line 54 - line 58; figure 2 *	12 2	
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TECHNICAL FIELDS SEARCHED (Int.Cl.6)
A61F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	2 January 2000	Deprun, M

CATEGORY OF CITED DOCUMENTS

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